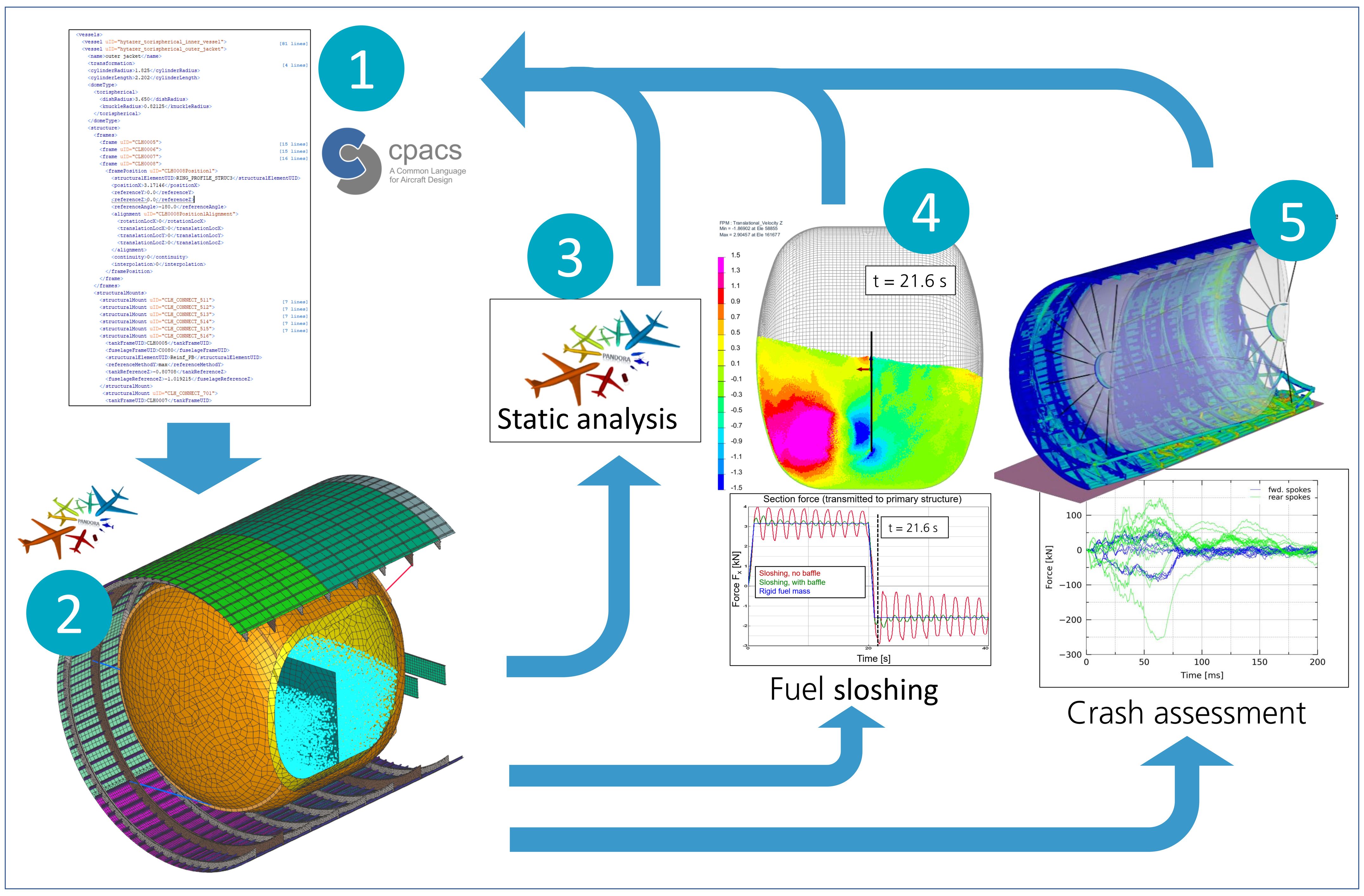
#ArchitectingAviation

LH2 POWERED AIRCRAFT - TANK INTEGRATION
Process chain to analyze LH2 fuselage tank integration

Targets: Tool chain development for quick assessment of various tank integration concepts
Consideration of flight loads and especially loads acting in emergency situations (e.g. RTO, crash)
Status: Work in Progress ➔ almost full tool chain to be available by end of 2025



General set-up of the process chain development for assessment of LH2 tanks: 1. CPACS data description 2. parametrical model generation, 3. static analysis, 4. fuel sloshing, 5. crash assessment

Design challenges for tank

- Cryogenic temperatures around 20K
- Isolation between tank hulls required (vacuum or foam)
- The tanks shall not carry fuselage deformation loads ➔ isostatic support (few mounts)
- Tank and tank mounts have to carry:
  - Internal pressure (2-4, max. 10 bar)
  - Sloshing loads (e.g. rejected take-off (RTO) and crash deceleration)
  - Crash loads (beyond CS25.561)

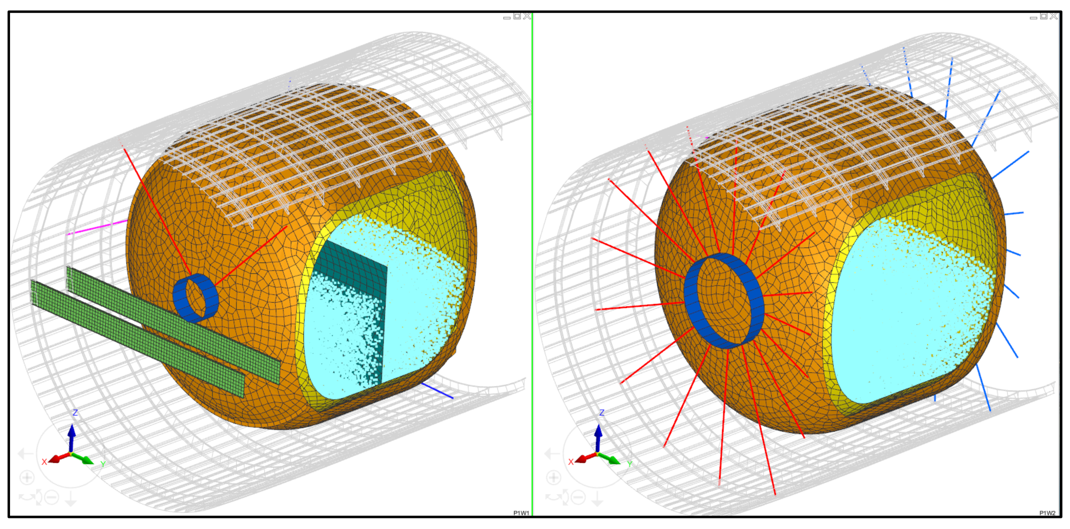
1. CPACS schema extensions

xml-format to describe aircraft and air transportation system in general

- Detailed aircraft primary structure description available since years
- Tank description should include
  - *vessels*: arbitrary number of hulls (incl. material / lay-up definition)
  - *stringers / frames*: reinforcements of the vessels
  - *walls*: internal walls (baffles)
  - *structuralIntegration:* structural integration into the airframe incl. *tank crossbeam, tankConnection, periodicTankConnection, …*

2. PANDORA design environment

- Significant enhancement in automatic model generation
- New features for geometrical modelling established
- Meshing of tank hulls and potential baffles using OS mesh tool gmsh
- Additional modelling option for liquid in the tank using solid mesh (TET) to be transferred to particles for SPH method



Modelling of alternative tank integration concepts:
- **Double shell tank with particle fluid representation**

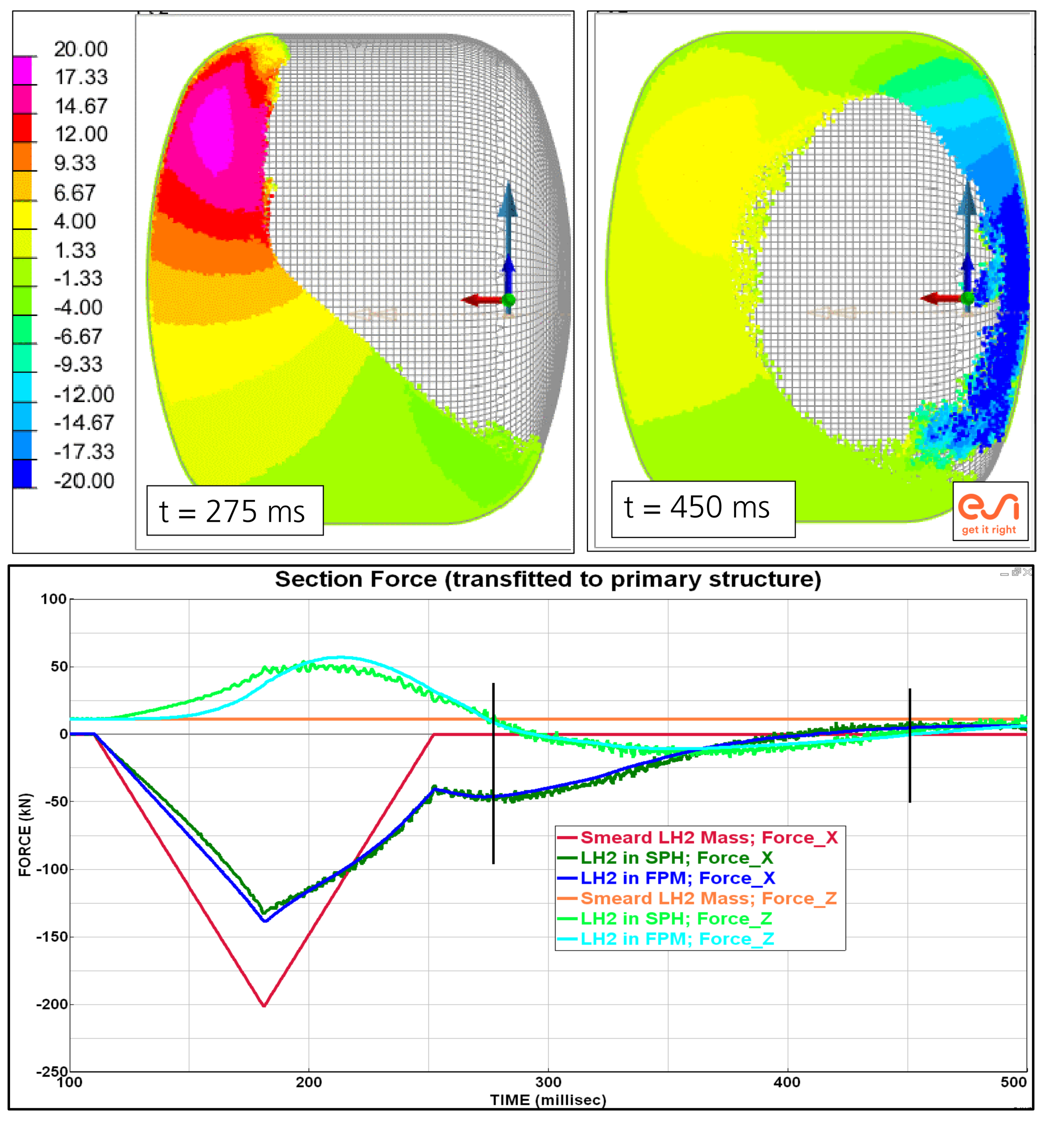
a. Backward polar mount and specific rods at the front
b. polar mounts with 16 spokes on either side / x-rods

3. Static Analyses (PANDORA)

- Classical fuselage sizing considering also loads transferred from LH2 tank
- Assessment of rel. motion between fuselage and tank (joint limits)
- Currently not in focus of development

4. Fuel (LH2) Sloshing

- Considered Load cases:
  - Rejected take-Off / 0.4g / 40 sec
  - Crash (x comp.) / 18g / .15 sec



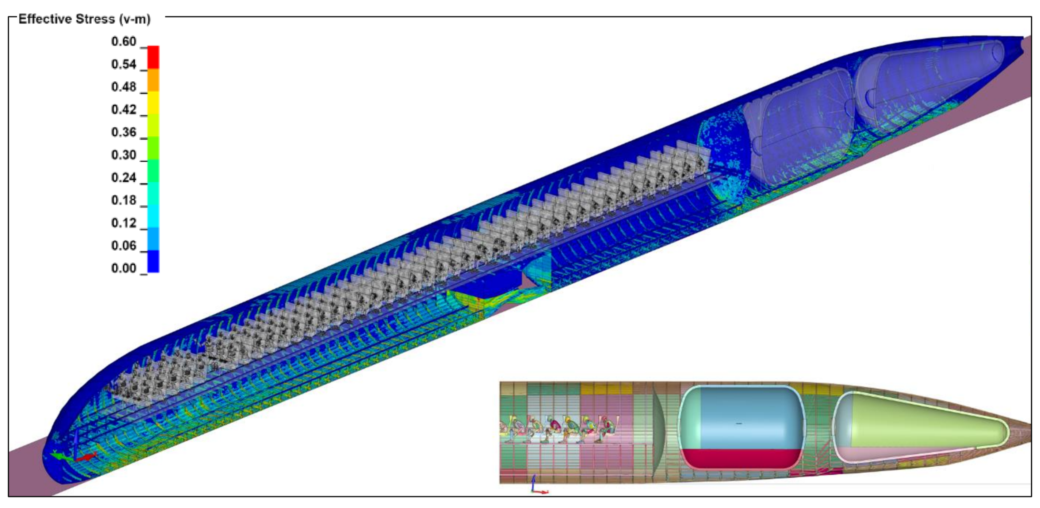
Exemplary results of fuel sloshing assessment using a 2-way coupled CFD / CSM method (FPM):
a. LH2 behavior under crash deceleration
b. Loads of tank acting on primary structure: smeared LH2 mass vs. two meshfree simulation results

Initial takeaways:

- Two meshfree numerical methods (SPH / FPM) successfully established to model Fluid-Structure Interaction in CSM code environment
- Loads from LH2 sloshing are not significant for sizing of the tank hulls, but may have an significant effect on the tank attachments!

5. Crash assessment

- Certification route not defined yet, special conditions expected with assessment on section / aircraft level



Exemplary results of aircraft crash simulation with combined initial loading: v_z = 30 ft/s (9.1 m/s), v_x = 262 ft/s (80 m/s), ϕ = 5.25° (pitch angle)

Initial takeaways:

- Need for full aircraft consideration
- Integration of dyn. fuel behavior foreseen by end of 2025 (SPH)

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